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The Sedimentary Basins of Australia and Papua - New Guinea and the Stratigraphic Occurrence of Hydrocarbons

Compiled by

Bureau of Mineral Resources, Geology and Geophysics

Paper Presented at Fourth ECAFE Symposium on the Development of Petroleum Resources of Asia and the Far East, Canberra, October - November 1969

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SUMMARY

This paper updates the reports presented at the Symposium on the Development of the Petroleum Resources of Asia and the Far East in Tokyo in 1965. These papers summarized the stratigraphy of the sedimentary basins of Australia and Papua-New Guinea as known at that time.

The most spectacular advances in the occurrence of hydrocarbons since 1965 have been in the offshore sedimentary areas where major reserves of oil and gas have been established in the lower Tertiary sands of the Gippsland Basin; encouraging indications of petroleum have been reported from the Cretaceous silty sands of the offshore Perth and Carnarvon Basins and the Permian and Carboniferous sands and calcareous sediments of the offshore Bonaparte Gulf Basin. Substantial gas discoveries have been made in the Miocene reef limestone of the Papuan Basin.

The major developments onshore have been the production of gas from sandy sediments in the Jurassic of the Surat Basin, the Permian of the Cooper Basin and the possibility of gas production from the Permian of the northern Perth Basin. The occurrence of significant evaporite deposits in the Devonian of the Adavale, Arckaringa and Canning Basins has been established from exploratory drilling.

Exploration in the immediate future will be concentrated in the prospective offshore areas of the Perth, Carnarvon, Bonaparte, Papuan and Gippsland Basins. There are also encouraging signs of a widespread upsurge in onshore exploration in eastern Australia as a result of recent farm-in agreements.

INTRODUCTION

This report updates the papers presented at the Symposium on the Development of Petroleum Resources of Asia and the Far East in Tokyo in November 1965 (Reynolds, 1965 and Thompson, 1965).

The sedimentary basins of Australia and Papua and New Guinea cover an area of approximately 1.7 million square miles (4.4 million sq. km.) - almost half the total land area. Recent offshore exploration on the continental shelves has added a further half million square miles (1.3 million sq. km.) of prospective area.

As a result of the intensive search for petroleum since 1950 the following fields were in production by March 1969:-

Field	Basin	Production
Moonie	Surat	4400 bopd
Alton	Surat	793 bopd
Roma area	Surat	15 mm cfd
Barrow	Carnarvon	34000 bopd
Barracouta	Gippsland	not available

It is expected that three further oilfields in the Gippsland Basin (Marlin, Kingfish and Halibut) will be producing at least 280,000 bopd and two gas fields in the Cooper Basin (Gidgealpa and Moomba) will be in production by the end of 1970.

The more important published references to the geology of the basins discussed are listed at the end of the paper. A large amount of unpublished information, including well completion reports and reports on geophysical surveys, is available from the library of the Bureau of Mineral Resources in Canberra, and has been drawn on in the summaries that follow.

ADAVALE BASIN

The Adavale Basin is a Devonian-Carboniferous Basin of about 11,000 square miles (28,000 sq. km.) in western Queensland. It is completely buried unconformably below Permian and Mesozoic sediments of the Great Artesian Basin (q.v.) up to 7000 feet (2100 m.) thick. It is contemporaneous with the early part of the Drummond Basin (q.v.) and may once have been continuous with it.

Known basement comprises Ordovician basalt and phyllite, and Silurian granite. The earliest deposits are Middle Devonian volcanics in the central part, which grade laterally into arkose. Later Middle Devonian sediments are mainly marine shale and sandstone with an evaporitic basin containing extensive salt bodies near the eastern margin. Conditions locally ranged through paralic to terrestrial. Slight earth movements during this period resulted in a widespread slight unconformity above which is a thin transgressive dolomite, one of the main seismic reflectors. Middle Devonian sediments are at least 5000 feet (1500 m.) thick.

Upper Devonian to Carboniferous sediments, up to 10,000 feet (3000 m.) thick are mainly red sandstone, shale and conglomerate, deposited in shallow seas and rapidly subsiding terrestrial basins.

Tanner (1967) attributes the main tectonism to the Carboniferous, with structures characteristically large-displacement normal faults with related gentle folds. Some mobilization of salt has caused folding, but no piercement structures are yet known.

A single gas field, Gilmore, was discovered in 1964 in the centre of the basin, with the reservoir in sandstone below the mid-Devonian unconformity. The field is not at present commercial. Subsequent exploration has failed to find any other encouraging leads, and in particular no petroleum has been found associated with the salt bodies. The Upper Devonian sequence is regarded as unprospective. There is little surface expression of the structures, so that exploration techniques have been predominantly geophysical. Depth to the prospective section, minimum 5000 feet, (1500 m.) and remoteness from pipelines and markets means that exploration is expensive and fields must be large to be economically exploitable.

REFERENCES: The most up-to-date published summary of the basin was given by TANNER (1967). Some unpublished work is discussed by GALLOWAY (in press).

AMADEUS BASIN

The Amadeus Basin is a Proterozoic and Palaeozoic basin - an intracratonic geosyncline - occupying some 60,000 square miles (150,000 sq. km.) in the Northern Territory and Western Australia. It is bounded and floored by Precambrian igneous and metamorphic rocks. To the east and west it is covered by younger sediments, and much of the basin is blanketed by Quaternary aeolian sand.

The Proterozoic succession consists of a basal quartzite sequence and a dolomite/siltstone/evaporite sequence which are more or less unchanged through the basin; and a varied sequence of neritic, paralic, and aqueoglacial rocks which is thickest in the south-central part of the basin - about 15,000 feet (4500 m.).

There followed a period of epeirogenic uplift during which some of the Cambro-Ordovician sediments were eroded away; deposition henceforward was transitional and continental. Minor movements during the Palaeozoic culminated in a major diastrophism, the Alice Springs Orogeny, in which folding and thrusting were aligned west-northwest and gave the basin its present form. During and after this orogeny thick continental sequences of siltstone, sandstone, and conglomerate were deposited ahead - that is, south - of the disturbance.

The formation of nappes and Jura-type folds during the Alice Springs Orogeny was aided by slippage and flow in evaporite beds in the Proterozoic and Cambrian successions. A line of diapirs along the centre of the basin can also be attributed to the evaporites, both from external pressure and from density differences.

Until recently the Amadeus Basin was not seriously considered as a possible petroleum producer, because of (1) the age of the succession, (2) the breaching of many structures, and (3) the remoteness from markets. In 1963, however, hydrocarbons were tapped in three wells. Present knowledge is of a little methane in Proterozoic shale and limestone, a little oil in Cambrian dolomite and sandstone, and substantial quantities of gas and some oil in Ordovician sandstone. The search is now directed to structures occulted below Devono-Carboniferous deposits and revealed by seismic reflection surveys.

REFERENCES: A comprehensive account of the Amadeus Basin is now in press (WELLS, FORMAN, RANFORD, and COOK). Accounts of parts of the basin may be found in Reports of the Bureau of Mineral Resources.

BONAPARTE GULF BASIN

The Bonaparte Gulf Basin in north-western Australia covers a land area of about 7000 square miles (18,000 sq. km.) and extends offshore over approximately 13,000 square miles (35,000 sq. km.).

The basement rocks consist of Proterozoic igneous rocks, metasediments and slightly deformed sediments overlain by Lower Cambrian volcanics.

The sedimentary section consists of 3500 feet (1070 m.) of marine Cambrian, 600 feet (180 m.) of marine Ordovician overlain unconformably by 6000 feet (1800 m.) of Upper Devonian including a reef complex and laterally equivalent lagoonal sediments. Sedimentation was continuous into the Carboniferous when 6000 feet (1800 m.) of sediments were deposited in the platform area. In the basinal area in excess of 9000 feet (2700 m.) of shale and siltstone was deposited.

In the northern part of the basin the Carboniferous sediments are overlain by 6000 feet (1900 m.) of mainly non-marine Permian sediments and scattered outcrops of Mesozoic. Recent drilling has indicated rapid thickening of the Mesozoic in the offshore extension of the basin.

Structure on the onshore part of the basin is associated with normal faulting and fault blocks; folding is rarely developed. Geophysical surveys have provided a general outline of the offshore development of the basin and have indicated an area of complex tectonics and folding on the western margin of the shelf, south of Timor.

Drilling for petroleum in the landward part of the basin has found gas in two wells: Bonaparte No. 2 Well produced 1.5 mmcfd. of 'wet gas' (8% or more of ethane and higher hydrocarbons) from sandstone lenses in a thick sequence of Lower Carboniferous siltstone and shale; and Keep River No. 1 produced dry gas from Devonian sandstone. The favourable areas of Palaeozoic rocks onshore lack major structures, and the rocks themselves have a low porosity.

Exploration has now moved offshore to structures defined by geophysical surveys in the Palaeozoic, Mesozoic and Tertiary sequence.

REFERENCES: VEEVERS and ROBERTS, 1968; KAULBACK and VEEVERS, 1969.

BOWEN BASIN

The Bowen Basin of Permian and Triassic sediments occupies some 33,000 square miles (85,000 sq. km.) in central-southern Queensland. It is floored by pre-Permian igneous, sedimentary, and metamorphic rocks. In the north and east its boundary is exposed; in the south it is overlapped by the younger Surat Basin (q.v.); and in the west it overlaps and lenses out over the Drummond Basin (q.v.) and older rocks.

The basin began as two separate depressions, both of which received thick sequences of non-marine deposits: volcanics and pyroclastics in the eastern trough, and fine and coarse clastics, with some coal, in the west.

General subsidence led first to marine sedimentation in each depression and then to general sedimentation over the whole area: first as pyritic mudstone and subgreywacke, and later as coarser clastics in shallower water. Further subsidence resulted in renewed deeper-water sedimentation of mudstone, limestone, and some sandstone. The whole sequence is 8000 feet (2500 m.) thick.

The Upper Permian saw a rapid regression of the sea and deposition of paludal sediments, including thick coal measures. In the late Permian the eastern part of the basin was uplifted and folded and the southern central part downwarped, and the basin assumed its present shape.

A thick sequence of Lower Triassic non-marine sediments was laid down in the depressions in the Basin, and continued movements through the Middle and Upper Triassic resulted in further shedding of detritus into the swamps and lakes of the basin. The total thickness of the Triassic succession is about 18,000 feet (5,500 m.). Part of the basin is blanketed by Cainozoic rocks.

Structurally, the basin is variable. The western part contains gentle folds and some compressional faulting: toward the northeast, where the thickest Permian sequence was laid down, tectonism increases and the rocks are strongly folded and faulted, metamorphosed to a low grade in places, and intruded by post-Permian plutons. In the south, folding is more gentle.

In considering petroleum potential the Bowen and Surat Basins must be linked, because wells drilled in the Surat Basin may have tapped hydrocarbons originating in the buried Bowen Basin. Oil is being produced from the Moonie and Alton Fields and gas and a little oil from the Roma Field. Potential source rocks occur in the Mesozoic and the marine Permian, and the earliest source may be Upper Carboniferous. The best reservoirs so far found are Lower Jurassic rocks of the Surat Basin, which may also contain source rocks.

Most known traps are combinations of structural and stratigraphic traps. The tectonism of the late Permian to Jurassic reduced the potential of the north and east of the basin, but enhanced that of the south and west.

REFERENCES: A comprehensive account of the Bowen Basin is being written in the Bureau of Mineral Resources. Several Reports of the Bureau deal with particular areas within the basin, and maps at 1:250,000 cover the whole basin. MALONE (1964) summarizes the depositional evolution of the basin. See also the Proceedings of the 8th Commonwealth Mining and Metallurgical Congress, 1965, Vol. 5.

CANNING BASIN

The Canning Basin covers an onshore area of 150,000 square miles (400,000 sq. km.). The offshore extension of the basin and the relationship with the offshore extensions of the Carnarvon and Bonaparte Basins have not been defined.

The basin has been divided into two areas; the Fitzroy Basin in the north is divided from the southern part of the Canning Basin by a subsurface ridge (Broome Ridge).

The Fitzroy Basin is a deep graben-like trough containing up to 30,000 feet (9000 m.) of Palaeozoic and Mesozoic sediments resting on Precambrian sedimentary, igneous, and metamorphic basement.

The shelf area along the northern margin of the Basin contains a well exposed complex of Devonian reef and associated sediments which unconformably rest on richly fossiliferous Ordovician sediments.
The remainder of the Palaeozoic sequence includes marine Carboniferous, Permian (marine, glacial, and lagoonal), and Mesozoic ranging from marine to terrestrial.

In the southern part of the Canning Basin the Permian-Mesozoic section is relatively thin and unconformably overlies an extensive development of Devonian and Ordovician sediments including evaporite sequences with bedded salt. At least 20,000 feet (6100 m.) of sediment is preserved in the deeper parts of the basin (Kidson Basin).

There is a marked contrast in structure between the Fitzroy Basin and the southern part of the Canning Basin. The Fitzroy Basin features large northwest-trending anticlinal structures in outcropping Permian sediments. This type of structure has also been detected by seismic surveys beneath the western margin of the basin, where structure is obscured by undisturbed Mesozoic sediments The Fitzroy Basin is further limited by large marginal faults with adjoining shelf areas of thinner sedimentation.

The southern part of the Canning Basin lacks surface structure, and seismic exploration has shown that the area is characterized by complex faulting and associated areas of deeper sedimentation rather than the development of well defined anticlinal trends as in the Fitzroy Basin.

The Canning Basin contains all the basic requirements for petroleum, including source-type rocks in the Ordovician, Devonian, and Carboniferous.

The only significant recovery of petroleum occurred in Meda No. 1 well, which recovered a few barrels of oil from lower Carboniferous sands on the northern shelf of the Fitzroy Basin. Considerable scope for further exploration remains throughout the basin, particularly in the shelf areas of the Fitzroy Basin and the untested offshore areas.

The main reference to the geology of the area is VEEVERS & WELLS (1961).

CARNARVON BASIN

The Carnarvon Basin is an elongated basin lying along the northwestern coast of Western Australia, and offshore. Its land area is 45,000 square miles (115,000 sq. km.). It is bounded to the south and east by Precambrian igneous and metamorphic rocks; the northeastern margin is obscured by Cainozoic sediments and the seaward margin has not been delineated.

The floor of the basin is very irregular: a strong meridional ridge runs through the centre of the onshore part of the basin, and it and lesser ridges divide it into subsidiary basins - the Gascoyne and Exmouth Basins west of the meridional ridge and the Onslow, Merlinleigh, Bidgemia, Byro, and Coolcalalya Basins to the east. The basins are grabens or half-grabens and the meridional ridge a horst probably formed in the Permian.

Thick Proterozoic and early Palaeozoic sediments cover the southeastern and southwestern parts of the floor of the Basin, and extend at least to the central eastern part. They were followed by some 7,000 feet (2,100 m.) of Devonian and Carboniferous sediments, mainly in the north.

The Permian succession has an overall thickness of 12,000 feet (3,650 m.). It is thickest east of the meridional ridge, but widespread through the basin. The sediments were mostly deposited in shallow water, but record a complex of environments: glacial near the base, followed by marine limestone and clastic sediments ranging from porous sandstone to dark siltstone and shale of deeper-water facies. A major break in deposition marks the end of Permian sedimentation.

Mesozoic sediments are best developed in the northern end of the basin. Triassic is known in the northern offshore area and in the Exmouth Basin. The Jurassic section is thick in the subsurface offshore and at Cape Range - 11,300 feet (3,400 m.) - and thinner elsewhere in the Gascoyne, Exmouth, and Onslow Basins; it is mostly of fine-grained clastics, and may be an important source for petroleum.

Cretaceous sediments occur in the Gascoyne, Exmouth, Onslow Basins and in the northern offshore area. They consist of a paralic lower unit, a neritic middle unit, and a carbonate upper unit, with a disconformity between the last two. The marine shales appear to be good source beds and the basal sand is certainly a good reservoir for any oil produced from the Jurassic sequence.

A Cainozoic sequence up to 2,000 feet (600 m.) thick caps the northern part of the Basin. It has no known potential for oil, but is not sufficiently well explored to be written off.

It seems unlikely that major tectonic stress has affected the Basin; faulting is mainly associated with sliding and compaction along hinge-line slopes, and most folds are basin downwarps and anticlinal drapes over the basement ridges. There may, therefore, be no vertical continuity in the structure, and each major sedimentary unit (between unconformities) may have its own distinct form.

Petroleum was first discovered in the Rough Range Anticline in 1954, when 500 bopd was produced from the basal Cretaceous sandstone. Gas shows were obtained from Jurassic mudstone in the parallel Cape Range Anticline, but not until 1964 was the sequence proved productive: the Barrow Island field now yields 34,000 bopd from Lower Cretaceous fine-grained sandstone.

Many Palaeozoic rocks have yielded shows of oil and gas, but no productive pool has yet been found The subsurface structure of the Basin, however, complex as it is because of lateral and vertical variation, is not yet fully elucidated, and the offshore section remains largely unknown. The Basin remains one of the most promising areas in Australia in terms of petroleum potential.

REFERENCE: The most complete and up-to-date account of the Carnarvon Basin is by CONDON (1965-68).

CLARENCE-MORETON BASIN

The basin covers an area of about 11,000 square miles (28000 sq. km.) but parts of the eastern and north-western margins are concealed by Tertiary volcanics and interbedded sediments. which together are more than 3000 feet (1500 m.) thick.

It is mainly a Triassic-Jurassic basin, floored by highly folded and faulted and mildly metamorphosed Palaeozoic sediments and volcanics which are intruded by granite and ultrabasic to basic rocks. Eastern and northern margins are mainly faulted, but the western margin is depositional. On the northwest the basin sediments merge with those of the Surat Basin (q.v.).

Rocks of the basin are divisible into two sequences. The lower one consists of coal measures and volcanics of Triassic age, overlain disconformably or unconformably by a sequence of uppermost Triassic to Upper Jurassic age, consisting of terrestrial clastics with some coal and only minor volcanics. The lower sequence contains up to 4300 feet (1300 m.) of the coal measures (shale, sandstone, coal and conglomerate) and 5000 feet (1500 m.) of volcanics which are thickest in the southern half of the basin. The upper sequence is generally not more than 7000 feet (2100 m.) thick.

Depositional conditions oscillated between paludal and fluvial on a piedmont plain, with brief periods of volcanic activity and interruptions due to tectonic activity. Recent palynological evidence indicates at least two brief marine incursions.

The basin formed as an intermontane depression, partly controlled by faults, and probably has altered little in outline since the Mesozoic. The sediments are locally strongly faulted and folded, but mainly within a near-meridional zone which continues northwards to join the eastern edge of the Esk Rift. Where detailed work has been carried out, particularly in the Ipswich Coalfield, numerous small normal faults have been reported. Igneous intrusions commonly have associated domes in the sediments.

Seven wells have been drilled in the basin. Minor gas shows associated with coal seams were reported, and small amounts of oil were recovered from a side-wall core and a drill stem test in one well in the centre of the basin. The occurrence was in the basal Jurassic sequence, which has the best porosity and permeability. Seismic prospecting is difficult due to strong relief caused by widespread resistant volcanics. These also reduce the attractiveness of large areas for petroleum search, particularly on the east side of the basin. In the north of the basin two wells reached Triassic volcanics at shallow depths, and these are presumed to be widespread. On the west arenites are argillaceous and tight, where they are close to sediment source areas. The most prospective areas appear to be in the centre and south of the basin.

REFERENCES: The most comprehensive published report is by McELROY (1962), which is mainly concerned with the New South Wales part of the Basin. Aspects of the Queensland portion are contained in HILL and DENMEAD (1960).

DALY RIVER - WISO BASIN

The Daly River Basin, in the northern part of the Northern Territory, contains about 1000 feet (300 m.) of Cambrian and Ordovician marine limestone and sandstone and is virtually undeformed. The extension of the basin to the south under a cover of Mesozoic sediments has been called the Wiso Basin. Subsurface knowledge of the Wiso Basin is restricted to geophysical data and shallow core holes.

Aeromagnetic and seismic surveys indicate the sedimentary section may range from 7,000 feet (2300 m.) to 12,000 feet (3700 m.)but this probably includes a considerable thickness of unprospective Proterozoic sediments. The lack of exploratory drilling precludes a reliable evaluation of the sedimentary section, but the petroleum potential is probably of a low order

The geology of the area has been mapped by the Bureau of Mineral Resources and maps of the whole area at 1:250,000 scale are or will shortly be published.

DRUMMOND BASIN

The Upper Devonian to Lower Carboniferous Drummond Basin sequence crops out over an area of approximately 10,000 square miles (25,900 sq. km.), mainly west but also east of the Anakie High in east central Queensland. The basin is a structural remnant of a large depositional basin that developed in the Tasman Geosyncline after the Tabberabberan Orogeny. In the past it has been customary to include all Devonian and Carboniferous rocks in the region in the Drummond Basin sequence; but angular unconformities exist between the Middle and Upper Devonian and between the Lower and Upper Carboniferous successions in the region of the Anakie High, and only the Upper Devonian and Lower Carboniferous rocks are now included in the Drummond Basin sequence. The Middle Devonian rocks are part of the basement and the Upper Carboniferous strata are part of the onlapping Galilee Basin Sequence.

Basement to the basin consists mainly of low-grade metasediments of early Palaeozoic age, small isolated areas of Middle Devonian sediments and volcanics, and granites which range in age from Middle

Ordovician to Upper Devonian.

The Drummond Basin sediments were laid down in a slowly subsiding intermontane region which was drained to the north. The continental sedimentation, which kept pace with subsidence at most times, merged to the north and northeast with the widespread marine and paralic deposition of the Hodgkinson and Yarrol Basins, and up to 40,000 feet (12,200 m.) of mainly fluvial and lacustrine quartzose sandstone, conglomerate, and mudstone were laid down. Vulcanism occurred intermittently. Subsidence below sealevel took place in the north during the early history of the basin The Drummond Basin sequence was folded in the middle of the Carboniferous, in the Kanimblan Orogeny, and the region transitional between the continental sedimentation of the Drummond Basin and the marine deposition of the Hodgkinson and Yarrol Basins is now occupied by younger granites and volcanics. Much of the Drummond Basin both east and west of the Anakie High is obscured by younger sediments and the Drummond Basin outcrop belt is only a small structural remnant of the original basin of deposition.

The Upper Devonian Lower Carboniferous succession has been tested for hydrocarbons in five widely spaced exploratory wells. They are part of a large number of wells sunk to the west and south of the Drummond Basin outcrop belt primarily to test the Upper Carboniferous, Permian, and Mesozoic rocks of the onlapping Galilee, Eromanga, and Surat Basins. The complete lack of exploratory wells with primary targets in the Drummond Basin sequence is a clear indication that the basin is regarded as a poor prospect for hydrocarbon accumulation.

REFERENCE: The geology of the Drummond Basin is described in a forthcoming publication of the Bureau of Mineral Resources (OLGERS, in prep.).

EUCLA BASIN

The Eucla Basin is a Tertiary basin marginal to the Great Australian Bight. The onshore area covers 74,000 square miles (190,000 sq. km.) and extends offshore over an area of similar size. The basin is generally shallow but deepens towards the coast, where approximately 4,000 feet (1,200 m.) of sediments (including Tertiary, Mesozoic and Palaeozoic) may occur. Up to 6,000 feet (1,800 m.) of sediments have been indicated by seismic surveys in the offshore area.

The lack of prospective section and anticlinal structure has inhibited exploration in the past. The possibility of thicker and younger sediments offshore should support further exploration offshore and eventually evaluation by drilling (SMITH, 1967).

GEORGINA BASIN

The Georgina Basin occupies a surface area of about 110,000 square miles (285,000 sq. km.) and extends in a belt trending north-west from western Queensland to the central part of the Northern Territory. The basin is bounded on the east, north and west by Precambrian rocks but the southeastern and northwestern boundaries are obscured by Mesozoic sediments.

Middle Cambrian sediments are regarded as the basal units of the succession, but in some marginal areas several thousands of feet of un-metamorphosed Upper Proterozoic/Lower Cambrian sediments underlie the Middle Cambrian sequence. The basin contains Cambrian and Ordovician marine sediments and a Devonian and/or Siluro-Devonian fresh-water sequence; the Cambrian units are widespread but Ordovician and Devonian outcrops are restricted to the southern half.

Most of the northern half of the basin contains a thin blanket of Middle Cambrian marine carbonate rocks, with minor shale and sandstone, which is usually less than 1000 feet (300 m.) thick. Some of these sediments are richly fossiliferous and may be source rocks for petroleum but most of the carbonate rocks are vuggy and cavernous and yield large quantities of water. The Middle Cambrian sediments have been strongly faulted along the northern margin but structural deformation is not evident elsewhere in the northern half of the Basin.

The thickest Palaeozoic sequences occur in the southern half of the basin, where 5000 feet (1500 m.) of Cambrian-Ordovician sediments are exposed. Middle to Upper Cambrian, and Lower Ordovician sequences consist predominantly of carbonate rocks and Middle Ordovician units consist of sandstone and shale; fossils are abundant in all sequences except the lower Upper Cambrian. The Devonian and Siluro-Devonian sediments consist mainly of sandstone.

The sediments in the southern and south-eastern parts of the Georgina Basin have been faulted and folded during the Alice Springs Orogeny, which occurred either in Upper Devonian or Carboniferous time. Most of the fold structures are associated with faults.

Nineteen exploratory wells have been drilled and all have been abandoned as dry holes; most tested Middle Cambrian sequences only, a few tested Upper Cambrian and Middle Cambrian, and only one spudded in the Middle Ordovician sequence. The petroleum prospects are considered poor in the northern half of the basin and are only slightly better in the southern half because, although favourable source, reservoir and cap rocks are known, the major structures are synclinal.

REFERENCE: K.G. SMITH (in press).

GIPPSLAND BASIN

The onshore part of the Gippsland Basin covers 3500 square miles (9100 sq. km.) and extends offshore into the Bass Basin in the west and the offshore Gippsland Basin in the east. The basement rocks consist of Devonian and older sedimentary, igneous, and metamorphic rocks.

The basin rocks consist of Permian sediments and volcanics, 8000 feet (2400 m.) of Mesozoic, and, unconformably over the Mesozoic, up to 6,000 feet (1800 m.) of Tertiary including both marine and terrestrial facies. Volcanic rocks have been penetrated in wells in the Tertiary and ?Mesozoic of the Bass Basin.

Recent seismic exploration in the basin, using the most advanced techniques, has indicated complex faulting and folding in the Mesozoic section and has outlined a large number of structural anomalies. Vigorous exploration is continuing in both the Gippsland and Bass Basins.

Hydrocarbons were obtained in 1924 in Oligocene glauconitic sand in Lakes Entrance No. 1 well; but it was not until 1965 that commercial accumulations were obtained in the basal Tertiary and Mesozoic of the Gippsland Basin.

Discoveries have been restricted to the Tertiary and Mesozoic sediments of the Gippsland Basin, and during the period 1965-1967, two gas/oil fields (Barracouta and Marlin) and two oil fields (Kingfish and Halibut) were discovered and will be in production during 1969.

Future exploration in both the Bass Basin and the Gippsland Basin will be directed towards the unravelling of the complicated geological history of the areas through the interpretation of seismic and exploratory well data. The basal Tertiary has been established as an important petroleum producing horizon. Deeper exploration in the structurally complex Mesozoic sediments may result in a significant increase in the reserves of the Gippsland Basin.

REFERENCES: HAFENBRACK (1966), REYNOLDS (1967).

THE GREAT ARTESIAN BASIN

The Great Artesian Basin has an area on land of 680,000 square miles (1,750,000 sq. km.), with possibly another 100,000 square miles (250,000 sq. km.) under the Gulf of Carpentaria. The term was originally used in a hydrological sense and, as such, does not match well with the usage of sedimentary basins elsewhere in this report. Briefly, a great blanket of Jurassic and Cretaceous sediments overlies several distinct basins of Permian-Triassic sediments and smaller remnants of older Palaeozoic basins.

The Jurassic and Cretaceous sediments occur in three distinct broad downwarps, the Surat, Eromanga, and Carpentaria Basins, separated by gentle basement swells, the Nebine and Euroka Ridges.

The Permian-Triassic Bowen Basin (q.v.) plunges southwards under the Surat Basin, and the Cooper and Galilee Basins are mainly buried below the western and northeastern Eromanga Basin. Except for the Devonian Adavale Basin (q.v.), areas of older Palaeozoic sediments under the Great Artesian Basin are only poorly known. Devonian evaporites occur in the Arckaringa Sub-basin, near the western margin of the Great Artesian Basin, and Lower Palaeozoic sediments, possibly a clastic facies of the Georgina Basin, occur below the Cooper and Pedirka Basins.

Basement is a complex of indurated and tightly folded sediments, low and high grade metamorphics, volcanics and igneous rocks of Precambrian and Palaeozoic ages

A large part of the Great Artesian Basin is but little disturbed structurally. Surface folds are generally broad and of low amplitude; the intensity of folding increases downwards where early Mesozoic and Palaeozoic sediments are present, but dips rarely exceed 10°. Faults or monoclines extending up to 100 miles (160 km.), but displacements of the order of 1000 feet (300 m) are characteristic, particularly in areas with less than 5000 feet (150 m.) of sedimentary cover.

Most of the structures were developing intermittently during sedimentation, with thicker and more complete sections in synclines than in adjacent anticlines. Many of the major anticlines are 'bald-headed', lacking the prospective parts of the section above basement ridges.

Development of the structures is interpreted as due mainly to vertical movements of basement blocks, possibly with some transcurrent movements. Reversals of the direction of movements of the blocks are uncommon.

The earth movements have continued at least into Tertiary time, when extensive movements on fractures were probably the reason for extrusion of much basalt along parts of the eastern margin of the basin. As much as 600 feet (200 m.) of unconsolidated sediments are present over some of the ancient downwarps, and this may indicate that earth movements have continued into the Quaternary.

REFERENCES: The published literature on the Great Artesian Basin and associated basins is extensive, but none is both comprehensive and up-to-date. The important summaries are, for Queensland, WHITEHOUSE (1954) and HILL & DENMEAD (1960); for New South Wales, BRUNKER et. al. (1967); and for South Australia, WARD (1946), and GLAESSNER & PARKIN (1958). More up-to-date papers concerning particular aspects or basins are SPRIGG (1961) on structures in the western part of the basin, WOPFNER (1964) on recent interpretations of geological history of the Cooper and part of the Eromanga Basin, KAPEL (1966) on the Cooper Basin, LINDNER (1966) on the Galilee Basin, VINE (1966) on the northern Eromanga Basin, and WOPFNER & ALLCHURCH (1967) on the Arckaringa Sub-basin.

CARPENTARIA BASIN

The Carpentaria Basin covers an area of 93,000 square miles (240,000 sq. km.) onshore, and possibly 100,000 square miles (250,000 sq. km.) offshore in the Northern Territory and Queensland.

A total section of less than 3000 feet (900 m.) is known onshore, although geophysical surveys indicate up to 6000 feet (1800 m.) offshore. So far seven wells have been drilled, all onshore, near the coast, including two on Mornington Island.

In the onshore part of the basin a thin basal sandstone sequence is overlain by 2000 feet (600 m.) of Lower Cretaceous marine mudstone, followed by several hundred feet of interbedded sandstone and mudstone deposited in shallow seas in late Lower and early Upper Cretaceous times. Most of the sandstone consists of volcanic detritus.

EROMANGA BASIN

The Eromanga Basin covers an area of 470,000 square miles (1,220,000 sq. km.) in central Queensland.

Sedimentation started early in the Jurassic, after earth movements and erosion had removed parts of the pre-existing basins. Throughout the Jurassic and into early Cretaceous time sedimentation was mainly in fresh water, and up to 2000 feet (600 m.) of sandstone and mudstone were deposited. A major marine transgression in Lower Cretaceous time was followed by deposition of between 1000 and 2000 feet (300-600 m.) of muddy sediments. An influx of volcanic detritus late in Lower Cretaceous time coincided with a major regression, and resulted in deposition of up to 5000 feet (1500 m.) of sandstone and mudstone, initially in paralic and later in freshwater environments.

A southern lobe of the basin, the Lake Frome Embayment, is a small depression underlain by Lower Palaeozoic sediments.

SURAT BASIN

The Surat Basin covers an area of 110 000 square miles (280,000 sq. km.) in southern Queensland and northern New South Wales.

The Surat Basin was the least stable of the three Jurassic-Cretaceous downwarps, and during the Jurassic and early Cretaceous received up to 5000 feet (1500 m.) of sandstone and mudstone. Most of the sedimentation was from fresh water, but there was at least one brief marine incursion during Lower Jurassic time. The Lower Cretaceous marine transgression was shorter-lived and not as widespread in the Surat Basin as elsewhere in the Great Artesian Basin. Less than 1000 feet (300 m.) of marine mudstone was deposited, overlain by up to 2000 feet (600 m.) of sandstone and mudstone deposited in paralic and freshwater environments.

The southern part of the Surat Basin, known as the Coonamble Embayment, was a more stable part with a thinner sequence. The southeastern tongue of the basin is a small Mesozoic depression called the Oxley Basin, which adjoins the Sydney Basin. The eastern side is an extensive thrust zone, which also defines the northeastern side of the Sydney Basin.

Two commercial oil fields (Moonie and Alton) have been found in two Lower Jurassic sandstones in the Surat Basin near the edge of an older trough. Numerous small gas fields, with some condensate and small amounts of oil in the area around Roma in the Surat Basin are mainly in Lower Jurassic sandstone occupying old valleys cut in the surface of a basement shelf. Source of the petroleum is generally regarded to be argillaceous sediments deposited during a brief marine incursion during the Lower Jurassic, but sources in deeper (Permian and

Triassic) sediments in the trough cannot be disregarded.

Most of the Jurassic and Cretaceous sediments are regarded as poorly prospective. Sandstones in the Jurassic to early Cretaceous sequence commonly have excellent porosity and permeability, but are saturated with fresh water.

GALILEE BASIN

The Galilee Basin is a large Permian-Triassic basin mainly buried below the Eromanga Basin, but protruding beyond the northeast margin. The full extent is not yet known, but is at least 60,000 square miles (155,000 sq. km.). The main area was a meridional trough northeast of Longreach, where up to 6000 feet (1800 m.) of Permian (including a basal conformable uppermost Carboniferous section) and 3000 feet (900 m.) of Triassic clastics were deposited. Throughout most of the basin only parts of the sequence are present, and are generally less than 1000 feet (300 m.) thick. The present interpretation is that sedimentation was almost entirely in freshwater environments but this is based upon limited data. Some of the Permian sediments are glacigene.

Not much drilling has yet taken place in the Galilee Basin, mainly because extensive seismic surveys have failed to show many closed anticlines. A good oil show was obtained from the base of the Permian sequence in Lake Galilee No. 1 in the deepest part of the basin, but there has been no subsequent encouragement to pursue the search.

COOPER BASIN

The Cooper Basin, straddling the border between Queensland and South Australia, is completely buried below the Eromanga Basin. Its extent is imperfectly known, but it has an area of about 50,000 square miles (130,000 sq. km.). It is mainly a Permian Basin in the south, with more than 3000 feet (900 m.) of sandstone, shale, and coal, whereas the northern part has a generally thin Permian sequence with more than 1000 feet (300 m.) of Triassic sandstone and shale. Sedimentation was mainly from fresh water, although paralic and marine conditions have been interpreted. The lower part of the Permian sequence was glacigene.

To the west of the Cooper Basin, and separated by basement ridges, the Pedirka Basin and Arckaringa Sub-basin have been investigated in much less detail. They appear to have comparable Permian sequences and may once have been connected with the Cooper Basin. Devonian evaporites were drilled in one well in the Arckaringa Sub-basin; a nearby dome is interpreted as a piercement structure.

A pipeline to tap the Gidgealpa and Moombah gas fields is at present under construction. Moombah gas contains some condensate. Both fields are in Permian sediments, which are probably the source rocks also, though underlying Lower Palaeozoic rocks could also have contributed.

Gas shows have been reported from Permian sediments elsewhere in the Cooper Basin, and oil shows from Triassic sediments, particularly in the northeast of the basin.

LAURA BASIN

The synclinal depression known as the Laura Basin lies within an older Basin, the Hodgkinson Basin, on the eastern side of Cape York Peninsula, Queensland. It is elongated northwest and its exposed area is about 7000 square miles (18,000 sq. km.): how far it extends offshore is not known.

The rocks of the basin are mainly Mesozoic; the full section consists of 230 feet (70 m.) of Permian mudstone, 2400 feet (730 m.) of Mesozoic sandstone and mudstone, partly marine, and 220 feet (67 m.) of Tertiary sediments.

The western side of the basin is faulted along pre-existing trends, and the eastern side is tilted only.

Potential source rocks in the Lower Cretaceous and Jurassic, and reservoir rocks higher in the section, give some prospect of oil accumulation, though the onshore section is too thin to arouse great expectations. Offshore prospects beneath Princess Charlotte Bay have not yet been evaluated; the area is being seismically surveyed at the time of writing.

REFERENCE: de KEYSER and LUCAS, 1969.

MARYBOROUGH BASIN

The basin is small, narrow and elongate along the Queensland coast, and about 9500 square miles (24,000 sq. km.) in area. The western side is an ancient fault zone; the full offshore extent is not yet known, and the outer part, separated by a basement swell is sometimes separated as the Capricorn Basin.

Folded Triassic sediments and volcanics up to 11,000 feet (3300 metres) thick are regarded as basement. Basin sediments are Jurassic and Cretaceous, with a thin Tertiary cover of basalt, sand and clay, up to 400 feet (120 metres) thick onshore and more than 1000 feet (300 metres) of marine sediments offshore.

Jurassic rocks of shale, sandstone, conglomerate and coal up to 6500 feet (2000 metres) thick are predominantly or wholly non-marine.

Cretaceous rocks contain a basal sequence of intermediate and acidic volcanics and some apparently non-marine clastics, estimated to be 4000 feet (1200 metres) thick; overlain by a marine sequence up to 8000 feet (2400 metres) thick of dark pyritic shale, sandstone and limestone; and overlain by an estimated 10,000 feet (3000 metres) of coal measures. Some small plutons, associated with the Lower Cretaceous volcanics, intrude older sediments.

The sediments were deposited in a trough, formed by prolonged subsidence of a basement block. Within the basin faulting is mainly near the western margin. It consists of a complex of small normal faults, generally parallel to the western bounding fault, with some discordant transcurrent folding. The sediments are strongly folded, with limb dips of the order of 30°, about axes trending parallel to the western bounding fault. Most folds are asymmetric, possibly reflecting deeper basement normal faulting.

The only parts of the sequence with sufficient permeability to provide reservoirs are the base of the marine Cretaceous, where sandstone beds have given small gas shows, and sandstone in the non-marine Jurassic sequence, which is mainly very deep. Tertiary sediments are marine, and permeable, but the full sequence is not yet known.

REFERENCES: A comprehensive report was given by ELLIS (1968); there are also several unpublished oil exploration company reports available for study at the Bureau of Mineral Resources and the Geological Survey of Queensland.

MURRAY BASIN

The Murray Basin is a large artesian basin of 100,000 square miles (250,000 sq. km.), partly covered by Cainozoic deposits, which extends from southeastern South Australia into southwestern New South Wales and northwestern Victoria. It is bounded on the southwestern side by a granite belt, on the west and northwest by Precambrian and Lower Palaeozoic rocks, and on the east and south by Silurian and Ordovician metamorphics. An east-west belt of Devonian to Lower Carboniferous sediments lies along the northern side.

Small thicknesses of Permian fluvioglacial sediments have been drilled in the western part (in Renmark North No. 1 well). In the east, 3800 feet (1160 m.) of Permian coal measures and marine siltstones occur between the Tertiary and the Ordovician phyllite basement in Jerilderie No. 1 Well. Lower Cretaceous marine beds extend from the northern side of the Basin into the northwest and are up to 1450 feet (440 m.) thick in North Renmark No. 1. Tertiary paralic and marine sediments up to 1600 feet (488 m.) thick cover a large part of the Basin.

Recent exploration has been concentrated in the zone of older sediments in the area east and northeast of Broken Hill. Thick sections of Devonian and older sediments are preserved in faulted downwarps. Only minor hydrocarbon shows have been reported from the sedimentary section, which is primarily a non-marine sequence.

Geophysical exploration is continuing along the northern margin of the basin and it is expected that this will lead to additional exploratory drilling in the lower Palaeozoic sediments.

Recent references to the geology of the area are in ROSE & BRUNKER, 1969, & WILSON, 1967.

NGALIA BASIN

The Ngalia Basin is a small intracratonic depression filled with Proterozoic, Cambrian, perhaps Ordovician, and Carboniferous sediments. It covers some 6000 square miles (15,000 sq. km.) in the southern part of the Northern Territory. It is floored by Precambrian igneous and metamorphic rocks.

The sediments of the basin are mostly shallow marine deposits, though they include Proterozoic glacials, Palaeozoic redbeds, and Carboniferous continental sediments.

The basin is asymmetrical: the axis of the deepest part (1600 ft or 5000 m.) lies towards the northern margin. The northern boundary is a thrust fault against basement, and the sediments are deformed. The southern margin is a normal depositional contact, and beds dip moderately into the basin; in places they are block-faulted and tilted.

The sequence shows signs of several epeirogenic movements, but the main deformation is due to two vigorous diastrophic episodes, one in the late Ordovician and the other after the Carboniferous sediments were laid down. The latter is responsible for most of the deformation and for the demarcation of the present basin.

The basin has not been thoroughly investigated as a source of petroleum, but prospects must be rated as low. Only exploratory drilling will allow a proper evaluation of the area.

REFERENCE: COOK & SCOTT (1967) reported a reconnaissance survey of the Ngalia Basin.

OFFICER BASIN

The Officer Basin is onlapped to the south by the younger sediments of the Eucla Basin in Western and South Australia. The basin is separated from the Canning Basin in central Western Australia by a subsurface basement ridge.

Although this extensive area is relatively poorly known, recent exploratory wells and geophysical exploration have provided a broad outline of the geology of the area, which covers 133,000 square miles (345,000 sq. km.).

The sedimentary section ranges from Proterozoic to Mesozoic and may include Permian, Devonian, and Ordovician. The lack of fossiliferous section has restricted accurate dating of the sediments. Yowalga No. 1 well in the eastern part of the basin penetrated 1335 feet (410 m.) of Mesozoic and Permian sediments above assumed Proterozoic sediments. Munjari No. 1 well, on the northeastern margin of the basin, penetrated presumed Devonian sediments to a depth of 9510 feet (2896 m.).

Geophysical data has indicated an asymmetrical structure with the deepest section along the northern margin. The thick sedimentary section interpreted from aeromagnetic surveys may include at least 8000 feet (2440 m.) of unprospective Proterozoic sediments.

The lack of encouraging sediments has retarded exploration in the area. A large part of the area is unexplored and further exploratory drilling is required before the geology of the basin can be reliably evaluated.

REFERENCE: KRIEG (1969).

ORD BASIN

The Ord Basin occupies an area of 7,500 square miles (19,000 sq. km.) south of the Bonaparte Gulf Basin on the boundary between Western Australia and the Northern Territory. Lower Cambrian basalt, about 3,300 feet (1000 m.) thick, overlies deeply eroded Upper Proterozoic sediments. The basalt is overlain, probably disconformably, by 1900 feet (580 m.) of Lower to Middle Cambrian limestone, partly gypsiferous shale and siltstone, and ferruginous sandstone and siltstone. Sandstone of probable Upper Devonian age, 1300 feet (400 m.) thick, unconformably overlies the Cambrian sequence.

The Palaeozoic sediments are preserved in three structural basins adjacent to the Halls Creek Fault. Folding of the Ord Basin was probably post-Devonian, and may have coincided with important late Permian movements in the Bonaparte Gulf Basin.

The only important occurrence of hydrocarbons is the report of asphaltite in the Lower Cambrian volcanics. Its origin is uncertain, but Upper Proterozoic rocks with more than 2000 feet of sediments including algal limestone, is a likely source. There is no exploration in the basin at present.

REFERENCE: DOW & GEMUTS (1969).

OTWAY BASIN

The Otway Basin contains Mesozoic and Tertiary sediments in onshore and offshore western Victoria and south-eastern South Australia: the basin has a total area of about 33,000 square miles (85,000 sq. km.). The basin trends east-west at the eastern end, but the trend swings to west-north-west in South Australia; these trends cut across the regional "grain" of Palaeozoic basement rocks, and the Otway Basin was controlled initially by faults.

The Otway Basin contains Tertiary, Upper Cretaceous and Lower Cretaceous-Jurassic? sequences, separated by regional unconformities. A characteristic feature of sedimentation is that where each of these unconformities occurs there is a cycle of marine transgression followed by transitional and regressive lithofacies. Basic intrusions, ranging in age from Quaternary to Lower Cretaceous-Upper Jurassic?, have been recorded in drilling operations.

The Tertiary sediments consist of limestone, marl, quartz sandstone with coal lenses, and conglomerate; the thickest sequences are in the offshore central part of the basin, where drilling has revealed about 4000 feet (1200 m.) of section. The Upper Cretaceous rocks do not crop out, but thick section, (up to 10,000 feet (3000 m.)) have been drilled in the central offshore area, and thicknesses ranging from 330 feet (100 m.) to 6500 feet (2000 m.) have been penetrated onshore. The irregular distribution of Upper Cretaceous sediments suggests that block faulting which formed horsts and grabens took place during deposition of the sediments. The Lower Cretaceous-Jurassic(?) sequence consists of subgreywacke, siltstone, mudstone, coaly beds and lenses, and orthoquartzite. Maximum thickness is about 8200 feet (2500 m.).

Possible source and reservoir rocks occur in each of the Tertiary, Upper Cretaceous and Lower Cretaceous-Jurassic(?) sequences; minor shows of gas and oil have been found at various levels in the Cretaceous sediments, mainly in porous sandstone, but no commercial production has been attained, although the Port Campbell No. 1 Well had an initial flow of 4 mmcfd of petroliferous gas. Most onshore wells have been in a belt roughly paralel to the margin of the Basin, in a zone where flushing is possible. Many of the wells have been drilled on structural culminations, but some stratigraphic traps have been tested unsuccessfully. Seven wells have been drilled offshore and no significant hydrocarbons were discovered. Present exploration is concerned with re-interpretation of extensive marine seismic surveys, and onshore search for stratigraphic traps.

REFERENCES: TAYLOR, 1964 & WHITE, 1968.

PERTH BASIN

The onshore part of the Perth Basin extends from the south coast of Western Australia for a distance of 600 miles (966 km.) to the north and covers an area of 21,000 square miles (54,000 sq. km.). The offshore extension of the basin is approximately twice the area of the onshore part.

The eastern margin is a prominent fault (Darling Fault) which separates Precambrian basement from a thick half graben of sediments which in the deeper parts may exceed 20,000 feet (6,000 m.) in thickness.

The prospective section consists of Permian (up to 6000 feet (1830 m.) of glacial, coal measures, and marine sediments), Mesozoic (approximately 15,000 feet (4,600 m.) of mainly non-marine sediments becoming more marine offshore) overlain by 2000 feet (600 m.) of

Tertiary in local downwarps.

Recent seismic surveys have confirmed the complex structural conditions in the Mesozoic and Palaeozoic sediments and it appears that the majority of the anticlinal closures are associated with faulting.

A potential gas field is being drilled in the Yardarino, Dongara area in the northern part of the basin. The production is from Permian sandstone with production rates up to 10 MMcfd.

Gas has also been recovered from the Triassic-Jurassic of Gingin No. 1 in the central part of the basin. Non-commercial oil has been recovered from the Cretaceous of Gage Roads No. 1 well (offshore from Perth) and non-commercial gas from the Permian of Whicher Range No. 1 in the southern part of the Perth Basin. There has been sufficient encouragement to ensure further intensive exploration in the Mesozoic-Permian section throughout the basin.

REFERENCES: JOHNSTONE & WILLMOTT, (1966).

PIRIE-TORRENS BASIN

The Pirie-Torrens Basin (of South Australia) is an elongated, meridional, structural basin of 9000 square miles (23,310 sq. km.) between Port Pirie, in the south and Lake Torrens in the north where it links with the Great Artesian Basin. The western margin is drawn from a pronounced fault line shown by B.M.R. aeromagnetic work in 1962. The eastern side follows the lower limits of Lower Cambrian sediments along the western scarp of the Flinders Ranges and their branch to the north-west. This side is also regarded as structurally controlled. The southern end opens into Spencer Gulf.

The oldest rocks known from the Basin are Cambrian dolomite and limestone up to 5000 feet (1524 ms.) thick, and these are overlain by thin Tertiary sediments which appear to be largely continental. Both the Cambrian and Tertiary beds contain oil shows.

The Pirie-Torrens Basin is a graben structure bounded by faults on the east and on the west. The graben has preserved Cambrian sediments at depth, and has been filled with Tertiary and Quaternary deposits.

The presence of possible source rocks has been indicated by drilling, and porous zones including reef facies occur in the Cambrian dolomite and limestone. The petroleum prospects of the basin are rated as low and no exploration is taking place.

REFERENCE: DALGARNO, 1964.

SAINT VINCENT BASIN

The Saint Vincent Basin was originally defined as a Cainozoic basin, but subsequent geophysical exploration and exploratory drilling has shown that extensive deposits of Permian and Cambrian sediments underlie the Cainozoic.

Cambrian sediments overlie basement rocks along the eastern and western margins of the basin. More than 4000 feet (1200 m.) of presumed Cambrian sediments were penetrated in Stansbury West No. 1 well on the western margin of the basin.

Cainozoic sediments, along the eastern margin and within Saint Vincent Gulf, are mainly paralic and at least 2000 feet (600 m.) thick.

The configuration of the basin is controlled by marginal block faulting.

Extensive seismic surveys within Saint Vincent Gulf and farther offshore have been completed, and offshore drilling can be expected in the future.

Past exploration has been directed towards the evaluation of the Cambrian sediments: in the future the offshore development of Permian and younger sediments may provide exploration targets.

REFERENCE: SPRIGG & STACKLER (1965).

SYDNEY BASIN

The Sydney Basin covers an onshore area of 12000 square miles (31,000 sq. km.) and extends eastwards along the continental shelf.

The sediments include 4000 feet (1200 m.) of mainly non-marine Triassic clastics, and an aggregate thickness of 16000 feet (4900 m.) of Permian marine and coal measure sediments. Extensive volcanic deposits occur in the lower part of the Permian in the southern part of the basin.

The structure of the basin is a half-graben with the thickest section adjacent to the fault zone along the northeastern flank. Several large anticlinal structures have surface expression along the northeastern margin.

Numerous wells have reported small gas flows in association with Permian coal measures, but poor reservoir conditions in the sandstone reservoirs have thwarted development.

The proximity of the largest concentration of population in Sydney promises a rich reward for petroleum exploration and consequently exploration can be expected to continue both onshore and in the undrilled offshore part of the basin.

REFERENCES: STUNTZ, 1965; KAMERLING, 1966.

TASMANIA

Several thousand feet of marine and continental sediments of Permian and Triassic age occur in the Tasmania Basin. These are extensively intruded by dolerite dykes and sills.

Recent exploration around the continental shelf of Tasmania has indicated an encouraging thickness of sediments, particularly on the northwest shelf. An exploratory well (Clam No. 1) is currently being drilled off the northwest tip of Tasmania.

REFERENCE: The main reference to the geology of Tasmania is SPRY & BANKS, 1962.

YARROL BASIN

The Yarrol Basin covers an area of 7000 square miles (18.000 sq. km.) in central coastal Queensland. The sedimentary section includes 7000 feet (2100 m.) of Mesozoic and at least 20,000 feet (6000 m.) of Palaeozoic. The sediments vary from marine to terrestrial and contain a high percentage of volcanic rocks and volcanic detritus.

The basin was subjected to strong tectonism at the close of the Palaeozoic, resulting in widespread faulting and local intrusions of igneous rocks. Relatively stable conditions during the Mesozoic resulted in the deposition of thick Triassic and Jurassic sediments.

The limited exploration in the area has indicated that prospects exist in the Mesozoic sections. The Palaeozoic sediments have been adversely affected by intense tectonism with a consequent reduction in petroleum potential.

REFERENCE: Reports on the area are available from the Geological Survey of Queensland.

OIL SHALES

Oil shales may be regarded as sources of hydrocarbons although from sources different from those already described.

Oil shale deposits are fairly numerous, and mainly associated with coal measures. The main areas of oil shale production were in the Sydney Basin and are associated with the Permian coal measures. The best deposits contain torbanite and may yield up to 150 gallons of oil per ton on distillation; these have been worked commercially in the past, but the most economical prospects have now been depleted.

Tasmania also has Permian oil shales ('tasmanite') in the northern part, west of Launceston, but these were formed mainly in marine or paralic environments.

Queensland occurrences range in age from
Permian - associated with coal measures in the Bowen Basin; and
Jurassic - also with coal measures in the Surat Basin, and north-west of Toowoomba in the Ipswich-Clarence Basin;
to Tertiary - small areas along old river valleys or in lacustrine environments
The Tertiary deposits occur west of Rockhampton near the eastern edge of the Bowen Basin, south-east of Rockhampton between the mainland and Curtis Island, two small areas north of the Maryborough Basin, and near Ipswich in the Ipswich-Clarence Basin.

Extensive deposits of oil shale have recently been announced in a press release. The deposits are in Lower Cretaceous marine sediments near the northern margin of the Eromanga Basin. Production feasibility studies are at present under way.

REFERENCE: TURNER, 1965.

PAPUA AND NEW GUINEA

INTRODUCTION

In the Territory of Papua and New Guinea, thick sequences of marine sediments ranging in age from Jurassic to Pliocene are prospective for oil and gas. Unmetamorphosed Triassic and Permian sediments are exposed in the central highlands; these sediments have not been recognized either at outcrop, or in the subsurface, in the flanking sedimentary basins. Low-grade metasediments within the median orogenic belt are regionally metamorphosed, particularly on the flanks of the Owen Stanley Range. The original form of the pre-Tertiary basins has been severely disfigured by Cainozoic orogenies which have produced the main present-day cordillera of New Guinea. The principal basins of Tertiary marine sedimentation, the Papuan Basin south of the highlands, and the Northern New Guinea Basin, north of the highlands, received floods of clastic sediments derived from recurring orogenic movements and associated volcanism along a zone now occupied by the highlands and mountain chains of New Guinea. The basin outlines shown on Plate 2 delimit the present distribution of unmetamorphosed Mesozoic and Tertiary sediments; they do not necessarily conform with the original basin margins before folding, emergence, and erosion. Only in the Papuan Basin can opposing basin flanks be confidently recognized. The Northern New Guinea Basin and the Cape Vogel Basin which are both truncated by the coastline are probably of the open marginal type. Undoubtedly, thick Tertiary to Recent sediments have accumulated in the offshore areas around the coastline of Papua and New Guinea and adjoining islands but, except off the coast of western Papua, deep water has precluded offshore oil exploration.

The information contained in this summary has been compiled mainly from published and unpublished reports by the staff of oil exploration companies and the Bureau of Mineral Resources. The principal source of geological information on western Papua is the review by Australasian Petroleum Company (A.P.C., 1961); unpublished well completion reports by this company and by Phillips Australian Oil Company have also been consulted. All sources of information cannot be acknowledged specifically in a review paper such as this, but the main published references are listed.

THE PAPUAN BASIN (Jurassic - Recent)

The Papuan Basin is a composite basin covering about 80,000 square miles (200,000 sq. km.) containing a thick Tertiary succession of marine and paralic sediments overlying, with degrees of unconformity, a Cretaceous and Jurassic succession. A major depositional or erosional break between Lower Cretaceous and Lower Miocene is widespread over most of the basin. However, Eocene limestone, rarely more than a few hundred feet thick, has been recorded from several localities, and is about 1000 feet (300 m.) thick in the wells Borabi, Uramu, Iviri and Muabu in western Papua. This limestone probably represents a relatively short period of marine transgression during the major period of widespread emergence between Cretaceous and Miocene deposition. This major break is not present in the Port Moresby area, where Upper Cretaceous, Eocene and Oligocene limestone, chert and tuffaceous sediments have been recorded, Palaeocene sediments are also known in this area; the relationship of this sequence to Lower Cretaceous sediments is not known.

The Pliocene sediments of the Papuan Basin are generally not as tightly folded as the Miocene sediments. Folding, erosion, and deposition progressed concomitantly during the Pliocene and clastic sediments with some coal interbeds, accumulated in paralic and deltaic environments in structurally and topographically depressed areas. In the Aure Trough, this concomitant folding and deposition has produced an effect of catenary folding with broad synclines containing thick Pliocene successions separated by sharp anticlinal crests on which the Pliocene sections are reduced or absent. In the southeastern part of the Aure Trough, the transgression of Pliocene clastic sediments over folded Upper Miocene sediments can be interpreted from aerial photographs.

The broad morphology of the Papuan Basin throughout Miocene time is fairly characteristic of a miogeosyncline, having:

(1) a broad, slowly subsiding southwestern shelf zone on which about 3,000 feet (900 m.) of limestone, with complex interplays of shoal and reef facies, accumulated.

(2) a deep asymmetrical trough (the Aure Trough) in which about 35,000 feet (10,500 m.) of alternating greywacke and mudstone were deposited rapidly, and

(3) a narrow northeastern shelf zone containing localized reef and shoal limestone lenses, and coarse clastic sediments derived mainly from basic to andesitic volcanism to the north and northeast.

Each of these three provinces has subsequently been deformed in a characteristic tectonic style which reflects both the competency of the sedimentary pile and the rigidity of the basement:

(1) In the extreme southwest, where a total Tertiary and Mesozoic sedimentary section, generally less than 10,000 feet (300 m.) thick, overlies granitic basement, folding is very broad and the Mesozoic section and basement have been dislocated by normal faulting. Farther northeast, but still in the province of Tertiary shelf limestone deposition, folding grades from broad and symmetrical to tight and asymmetric as the Miocene reef front, approximating to the Erave-Wana Swell (Plate 2) is approached. At Iehi and Puri near this hinge-line, steep and low-angled thrust faulting of both the Tertiary and Mesozoic sections has been recorded.

(2) Beyond the carbonate front, the thick (35,000 feet approximately) Lower Miocene to Pliocene fine-grained clastic succession of the Aure Trough is tightly folded; many folds are crestally thrust-faulted and incompetent mudstones and siltstones have diapirically ruptured the cores of some folds. Major strike faults in this zone probably have considerable horizontal, as well as vertical, displacements.

(3) On the narrow northeastern flank, where conglomerate, limestone, and volcanics are present within the sedimentary sequences, folding is more robust and crestal faulting less prevalent than in the thicker, less competent, sedimentary pile of the Aure Trough.

The pattern of Cretaceous and Jurassic deposition is less clear. The thick marine Mesozoic clastic sections (9,000 - 22,000 feet; 2700-6700 m.) in the Western and Eastern Highlands Districts of New Guinea suggest marine trough deposition, but the axis of the trough cannot be traced. In this same region Permian and Triassic sediments were deposited on, or associated with, intermediate to acid plutonic and volcanic rocks. The belt of basic and ultramafic intrusive and volcanic rocks north of both the central highlands and the Morobe Arc may represent a zone of late Cretaceous orogeny in the trough of an orthogeosyncline. Superimposed Cainozoic orogeny and probably transcurrent fault displacements make reconstruction of the pre-Tertiary continental margin virtually impossible. There is no evidence to suggest that the principal axes of Mesozoic and Tertiary deposition in the Papuan Basin are coincident. It has not been possible to detect with certainty any angular discordance between the Cretaceous and Tertiary either in outcrop or in wells in the Papuan Basin. However, the drilling of the Komewu No. 1 and No. 2 wells on either side of the Komewu Fault has indicated about 3,000 feet (900 m.) of vertical displacement of the Mesozoic succession before erosion and transgression by Lower Miocene limestone.

Surface showings of oil or gas are known in sediments ranging from Jurassic to Pliocene age. Most of the oil showings are impregnations in sediments which will either produce an oil film when freshly broken under water or have a distinct petroliferous odour when broken. No large free-flowing oil seepages are known, but oil can be collected from many small seepages by skimming the surface of the water in freshly dug collecting pits. Oil films and odours are also frequently associated with gas blows, even though in most cases the gas is "dry".

After almost 30 years of investigation, some encouragement was received in 1958 from the short-lived production of oil and "wet" gas during the testing of sub-thrust wedge of fractured Lower Miocene limestone in the Puri Anticline on the southwestern hinge of the basin. A well on the Bwata Anticline 15 miles (24 km.) northwest of Puri was designed to test the top of the lower Miocene limestone within anticlinal closure. The well spudded in upper Miocene mudstone and intersected the target limestone at 4750 feet (1448 m.). On test the interval 4750-5266 feet (1448-1605 m.) produced "lean gas" in excess of 25,000,000 cubic feet per day; this gas yielded condensate at the rate of 0.23 gallons per 1000 cubic feet. No liquid petroleum was produced and the well was plugged and abandoned.

Large quantities of "dry" gas were indicated in tests of Cretaceous sandstones at Barikewa and Iehi and gas under high-pressure was encountered at the top of a thick Miocene limestone succession at Kuru.

Since 1965, exploration in the Papuan Basin has been directed mainly towards offshore areas in the Papuan Gulf. The exploration wells Borabi, Iviri, Uramu, and Pasca all intersected Miocene reef limestone; a test of the limestone in Pasca No. 1 produced a maximum flow of 8.06 mmcfd of gas plus 101 bbs/hr. of condensate, but another test lower in the hole produced only 1.64 mmcfd gas + 97-1270 bbl/day salt water and the well was plugged and abandoned. Uramu IA produced gas from the Lower Miocene limestone at rates up to 24.4 mmcfd plus 2 bbl/hr condensate; the well is suspended. These wells confirmed the broad western shelf of the Papuan basin as a province of hydrocarbon-bearing platform-type reefs.

The wells Kapuri, Iokea, Maiva and Orokolo penetrated Neogene clastic sediments and volcanics; Kapuri bottomed in lower Pliocene reefal limestone, Iokea and Maiva in probably upper Miocene volcanics and Orokolo in lower Pliocene mudstone. The apparent absence of sealed reservoir rocks in this part of the basin is discouraging.

THE NORTHERN NEW GUINEA BASIN (Miocene - Pliocene)

The name Northern New Guinea Basin is applied loosely to a zone of thick Miocene and Pliocene clastic sedimentation north of the central highlands of New Guinea. The present-day southern limit of the basin is topographically expressed by the front of the main cordillera which, in the region of the Markham and Ramu Valleys, is fault-controlled. The basin is elongate, extending northwest into West Irian and southeast at least to the Huon Peninsula. The offshore limits are not known, but the principal axis of deposition probably lies offshore, so that only the southern flank is represented onshore. The onshore part covers about 32,000 square miles (83,000 sq. km.).

The aggregate thickness of Miocene and Pliocene clastic sediments in the region of the Bewani-Torricelli Mountains is about 35,000 feet (10,500 m.). The Pliocene part of this succession comprises dominantly non-marine coarse to fine-grained clastics with some coal interbeds; the Miocene part is essentially marine greywacke and mudstone with globigerinal marl interbeds. In the Sepik Valley the total section is thinner and the facies suggest shelf deposition. A late Tertiary orogeny has produced the Bewani, Torricelli, and Prince Alexander Mountains, which have cores of granitic, dioritic, and metamorphic upfaulted basement. The Tertiary sediments on the northern flanks of these mountains are very complexly folded and faulted. Oil seepages and gas flows occur in shear zones in diorite at Matapau near the coast between Wewak and Aitape and near Cape Terebu, about 8 miles (13 km.) southeast of Wewak.

Slight oil impregnations in Miocene and Pliocene sediments have been recorded from many localities in this part of the basin. Complicated tectonics and the predominance of sediments with low permeability have discouraged intensive oil exploration.

At the southeastern end of the basin, inland from Madang and north of the Ramu River, a thick coarsely clastic and partly volcanic upper Miocene and Pliocene succession is broadly folded. Some gas seepages from folded Tertiary sediments on the northern flank of the Ramu valley are known.

At the extreme southeastern end, in the rugged Finisterre, Saruwaged, and Cromwell Mountains of the Huon peninsula, a very thick, dominantly volcanic, Miocene section has been uplifted, folded and faulted in Pleistocene to Recent time. This part of the basin has very poor oil prospects.

During the period 1930 to 1940 most of the basin was reconnoitred geologically. Since the war, oil exploration companies have shown little interest in the area and no deep test wells have been drilled. Some shallow drilling was done in the period 1924 to 1926 near the Matapau oil seepages and shallow core drilling for geological information near Waniwa and Napsiei in the Upper Sepik valley was completed in 1957. In 1926, a well was drilled to 2,705 feet (824 m.) at Marienburg near the mouth of the Sepik River, but the results were not encouraging.

In 1964 American and French oil companies were granted Petroleum Prospecting Permits in this basin and geological investigations are continuing.

CAPE VOGEL BASIN (Middle Miocene to Recent)

The Cape Vogel Basin includes the thick folded sedimentary sequence which forms Cape Vogel. It is exposed over an area of about 5,000 square miles (13000 sq. km.) and may extend to the northwest beneath Recent coastal plain alluvium and volcanics. Deeply eroded sediments on the southern shore of Goodenough Bay and along the coast farther to the southeast may also be included in the basin. The offshore limits are not known.

The principal fold on Cape Vogel has an exposed core of basic submarine lava of probable Lower Tertiary age which has been intruded by Pliocene or younger basalt. A veneer of Palaeogene limestone, marl and conglomerate overlies the submarine volcanic basement in the Castle Hill area.

The main sedimentary sequence exposed on Cape Vogel comprises about 13,000 feet (4000 m.) of upper Miocene and Pliocene sandstone, conglomerate, and marl deposited rapidly in the paralic environment of a coastal plain bounding an active fault block of low-grade metasediments and basic to ultrabasic intrusives. Grey foraminiferal Pliocene marl, about 1,000 feet (300 m.) thick, on the northern part of Cape Vogel may have oil-source potential, but conditions for the entrapment of oil from this source do not appear to be present.

The principal fold on Cape Vogel has an exposed core of basic submarine volcanics. Basin tuffs, lapilli beds and agglomerate occur throughout and unconformably on the thick clastic sequence.

Carbon dioxide seepages and hot springs in the Cape Vogel area are probably related to decadent volcanism.

In 1928 the area was examined by geologists of the Anglo-Persian Oil Company. Two shallow wells drilled by the Cape Vogel Petroleum Co. in 1927 and 1928 near the former village of Kukuia on the southern flank of the Cape Vogel Anticline did not yield any confirmed evidence of either oil or gas. General Exploration Co. of Australasia carried out a preliminary survey of Cape Vogel in 1968.

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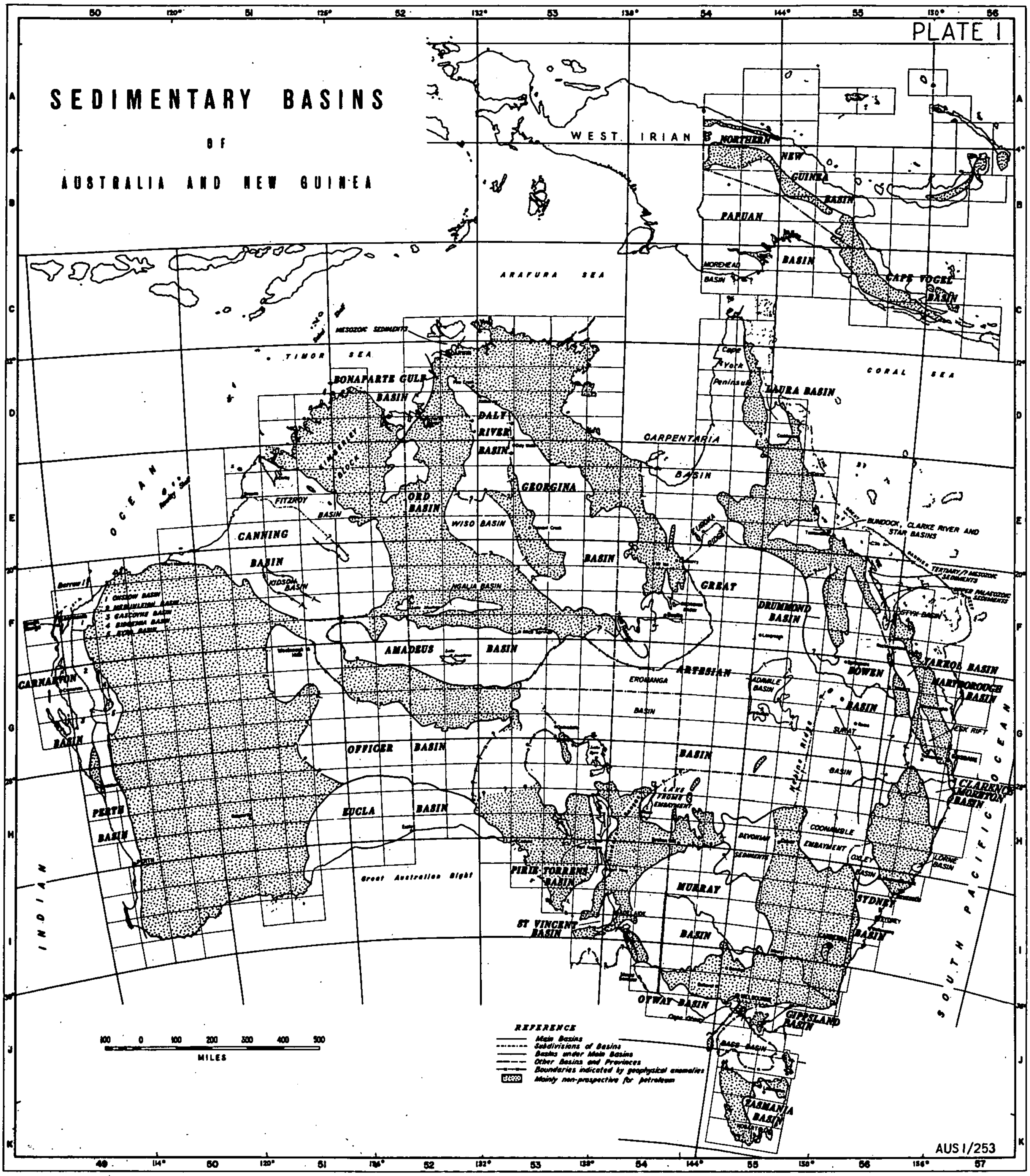
PLATE I
SEDIMENTARY BASINS
OF
AUSTRALIA AND NEW GUINEA
WEST IRIAN
NORTHERN NEW GUINEA BASIN
PAPUAN BASIN
MOREHEAD BASIN
CAPE VOGEL BASIN
ARAFURA SEA
TIMOR SEA
CORAL SEA
MESOZOIC SEDIMENTS
BONAPARTE GULF BASIN
DALY RIVER BASIN
LAURA BASIN
CARPENTARIA BASIN
GEORGINA BASIN
ORD BASIN
WISO BASIN
FITZROY BASIN
CANNING BASIN
KIDSON BASIN
NGALIA BASIN
AMADEUS BASIN
GREAT ARTESIAN BASIN
DRUMMOND BASIN
BOWEN BASIN
SURAT BASIN
EROMANGA BASIN
ADAVALE BASIN
BUNDOCK, CLARKE RIVER AND STAR BASINS
TERTIARY/? MESOZOIC SEDIMENTS
UPPER PALAEOZOIC SEDIMENTS
STYX BASIN
YARROL BASIN
MARYBOROUGH BASIN
ESK RIFT
CLARENCE-MORETON BASIN
LORNE BASIN
1 ONSLOW BASIN
2 MERLINLEIGH BASIN
3 GASCOYNE BASIN
4 BIRDRONG BASIN
5 BYRO BASIN
CARNARVON BASIN
PERTH BASIN
OFFICER BASIN
EUCLA BASIN
Great Australian Bight
PIRIE-TORRENS BASIN
ST VINCENT BASIN
LAKE FROME EMBAYMENT
MURRAY BASIN
DEVONIAN SEDIMENTS
COONAMBLE EMBAYMENT
OXLEY BASIN
SYDNEY BASIN
OTWAY BASIN
GIPPSLAND BASIN
BASS BASIN
TASMANIA BASIN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
Cape York Peninsula
100 0 100 200 300 400 500
MILES
REFERENCE
Main Basins
Subdivisions of Basins
Basins under Main Basins
Other Basins and Provinces
Boundaries indicated by geophysical anomalies
Mainly non-prospective for petroleum
AUS I/253

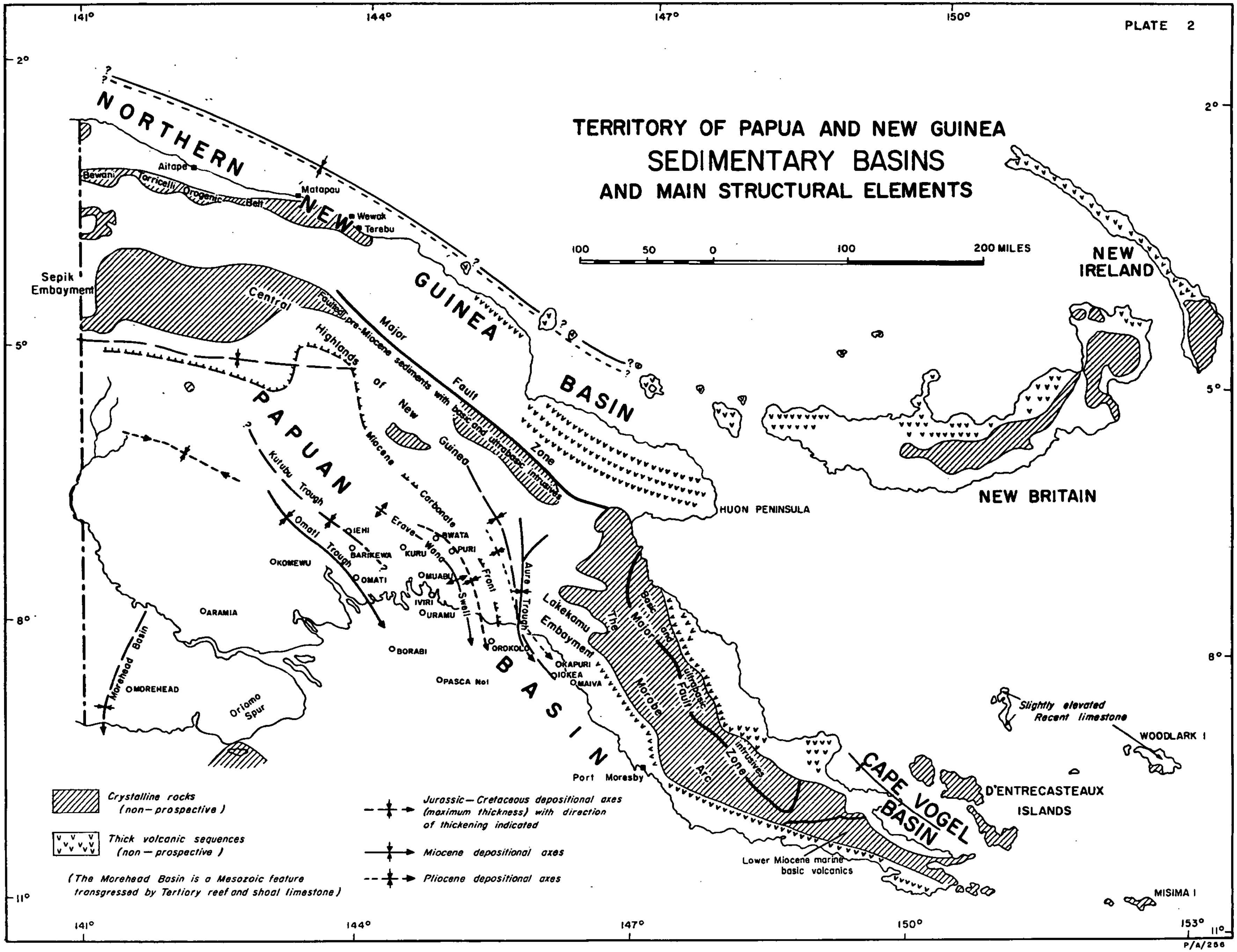
PLATE 2
TERRITORY OF PAPUA AND NEW GUINEA
SEDIMENTARY BASINS
AND MAIN STRUCTURAL ELEMENTS
100 50 0 100 200 MILES
141°
144°
147°
150°
153°
2°
5°
8°
11°
NORTHERN NEW GUINEA BASIN
PAPUAN BASIN
CAPE VOGEL BASIN
Bewani Torricelli Orogenic Belt
Aitape
Matapau
Wewak
Terebu
Sepik Embayment
Central Highlands of New Guinea
Faulted pre-Miocene sediments with basic and ultrabasic intrusives
Major Fault Zone
Miocene Carbonate Front
Kutubu Trough
Omati Trough
Erave-Wana Swell
Aure Trough
Lakekamu Embayment
The Morobe Arc
Basic and ultrabasic intrusives
Major Fault Zone
Morehead Basin
Oriomo Spur
IEHI
BARIKEWA
KURU
OMATI
KOMEWU
ARAMIA
WATA
PURI
MUABU
IVIRI
URAMU
BORABI
OROKOLO
KAPURI
IOKEA
MAIVA
PASCA No1
MOREHEAD
Port Moresby
HUON PENINSULA
NEW BRITAIN
NEW IRELAND
D'ENTRECASTEAUX ISLANDS
WOODLARK I
MISIMA I
Slightly elevated Recent limestone
Lower Miocene marine basic volcanics
Crystalline rocks (non-prospective)
Thick volcanic sequences (non-prospective)
(The Morehead Basin is a Mesozoic feature transgressed by Tertiary reef and shoal limestone)
Jurassic—Cretaceous depositional axes (maximum thickness) with direction of thickening indicated
Miocene depositional axes
Pliocene depositional axes
P/A/256